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1. Your reference — PHGB030135GBP

2. Patent application number *(The Patent Office will fill this part in)* — 0410905.4

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   KONINKLIJKE PHILIPS ELECTRONICS N.V.
   GROENEWOUDSEWEG 1
   5621 BA EINDHOVEN
   THE NETHERLANDS

   Patents ADP number *(if you know it)* — 07419294001

   If the applicant is a corporate body, give the country/state of its incorporation — THE NETHERLANDS

4. Title of the invention
   COMMUNICATION SYSTEM AND METHOD OF OPERATING THE COMMUNICATING SYSTEM

5. Name of your agent *(if you have one)*

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*
   PHILIPS INTELLECTUAL PROPERTY & STANDARDS
   CROSS OAK LANE
   REDHILL
   SURREY, RH1 5HA

   Patents ADP number *(if you know it)* — 08359655001

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	0318735.8	11/08/03

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Number of earlier UK application	Date of filing *(day / month / year)*

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   Answer YES if:
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   b) there is an inventor who is not named as an applicant, or
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   Otherwise answer NO (See note d)

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	
Description	8
Claim(s)	5
Abstract	1
Drawing(s)	3

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Priority documents	NONE
Translations of priority documents	NONE
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	NONE
Request for a preliminary examination and search (Patents Form 9/77)	NONE
Request for a substantive examination (Patents Form 10/77)	NONE
Any other documents (please specify)	NONE

11. I/We request the grant of a patent on the basis of this application.

Signature(s) P.J. Mabey   Date 13/5/04

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

PETER MABEY
Tel. 01293 815576   peter.mabey@philips.com

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DESCRIPTION

COMMUNICATION SYSTEM AND METHOD OF OPERATING THE COMMUNICATING SYSTEM

The present invention relates to a communication system, to a station for use in a communication system, and to a method of operating a communication system. The present invention has particular, but not exclusive, application to spread spectrum systems such as UMTS (Universal Mobile Telecommunication System).

Terminals in mobile communication systems usually have a maximum transmit power limit, which may be set by physical constraints or in response to an instruction received from a controller.

In a communication system while a terminal is transmitting a first signal, it is sometimes necessary to transmit simultaneously additional signals which would require the terminal's maximum transmit power limit to be exceeded. In such cases, a variety of approaches may be taken, including reducing the transmit power of the first signal in order to allow sufficient power for the additional signal(s) to be transmitted without breaching the maximum power limit or switching-off part or all of the first signal in order to allow the additional signal(s) to be transmitted.

In some systems, it is only possible to execute the reduction in transmit power of the first signal at particular time instants, such as a frame- or timeslot-boundary. These time instants may not correspond to the times at which the transmission of the additional signal(s) must commence. A method of overcoming this problem is to execute a reduction in transmit power in advance of the transmission of the additional signal(s).

In such situations, the exact nature of the additional signal(s) may not yet be known at the time when the reduction in transmit power of the first signal has to be executed because, for example, there is insufficient time for the terminal to evaluate a critical feature, such as a CRC (cyclic redundancy

check) in a received signal. Different types of additional signal may have different transmit power requirements.

An object of the present invention is to be able to transmit an additional signal in a timely manner whilst not exceeding a predetermined maximum power limit.

According to a first aspect of the present invention there is provided a method of operating a communication system comprising a first station and a second station, the first and second stations each having transceiving means, the second station transmitting a first signal to the first station, the power of the transmitted first signal not exceeding a predetermined maximum level, wherein in response to the second station wishing to transmit any one of a set of possible additional signals, the transmit power of the first signal is scaled by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

According to a second aspect of the present invention there is provided a communication system comprising a first station and a second station, the first station and second stations having transceiving means, the second station having power control means for controlling the transmitted power level of a first signal to be transmitted to the first station, wherein the power control means is adapted, in response to determining that the second station wishes to transmit any one of a set of possible additional signals simultaneously with the first signals, to scale the transmit power of the first signal by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

According to a third aspect of the present invention there is provided a second station for use in a communication system comprising a first station and a second station, the second station including transceiving means for communication with the first station, and power control means for controlling the transmitted power level of a first signal to be transmitted to the first station, wherein the power control means is adapted, in response to

determining that the second station wishes to transmit any one of a set of possible additional signals simultaneously with the first signals, to scale the transmit power of the first signal by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

The method in accordance with the present invention avoids setting a requirement on the terminal to make an earlier decision about which type of additional signal is to be transmitted, or to make a reduction in power of the first signal at some time other than the most convenient or required instant.

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is a block schematic diagram of an UMTS communication system,

Figure 2 is a simplified block schematic diagram illustrating the downlink and uplink signals,

Figure 3 is a timing diagram showing individually the uplink signals,

Figure 4 is a timing diagram showing the combination of the uplink signals, and

Figure 5 is a flow chart illustrating an embodiment of the method in accordance with the present invention.

In the drawings the same reference numbers have been used to indicate corresponding features.

The UMTS communication system comprises at least one base station BS and a plurality of mobile stations MS, one of which is shown in Figure 1. The mobile stations are able to roam within the radio coverage of the base station(s) and maintain radio communication by way of spread spectrum signalling on downlinks from the base station(s) and uplinks from the mobile stations. As is customary with spread spectrum signalling several signals can be transmitted simultaneously each signal having its own signature or spreading code selected from a set of signatures. Additionally power control

has to be effected to prevent weaker signals being swamped by more powerful signals. Accordingly a base station can specify the maximum power at which a mobile station can transmit on the uplink.

Referring to Figure 1, the base station BS is controlled by a controller 10 which carries out the many functions involved in the maintenance of the system and the sending and receiving of signals. A transceiver 12 is coupled to an antenna 14 for the transmission and reception of spread spectrum signals. An external source of data 16 is coupled to a base band stage 18 in which data is formatted into packets. The data packets are prepared for transmission by multiplying them in a multiplier 20 with a signature, for example a pseudo random code, obtained from a code store 22 under the control of the controller 10. The spread spectrum signal is passed to the transceiver for modulation and transmission.

In the case of a signal received at the antenna it is demodulated and despread by multiplying the demodulated signal with the appropriate signature. Thereafter the despread signal is passed to the base band stage 18.

The mobile station MS is controlled by a controller 30 which carries out the many functions involved in the operation of the mobile station, including the sending and receiving of signals. For convenience of illustration and to facilitate an understanding of the present invention the controller 30 is shown as comprising a microprocessor 32, a transmit power controller 34 and a power scaler 36. A transceiver 38 is coupled to an antenna 40 for the transmission and reception of spread spectrum signals from the base station BS. A man/machine interface 42, which includes a base band data formatting and deformatting stage, means for inputting data and means for outputting data, is coupled to a multiplier 44 to which is supplied a signature, for example a pseudo random code, obtained from a code store 46 under the control of the microprocessor 32. A signal to be transmitted on the uplink is spread and is passed to the transceiver 38 for modulation and transmission.

In the case of a downlink signal received at the antenna 40 it is demodulated and despread by multiplying the demodulated signal with the

appropriate signature. Thereafter the despread signal is passed to the man/machine interface 42.

In the case of UMTS the operating standard requires each mobile station to transmit spread spectrum uplink signals substantially continuously. These signals are formatted into successive frames or time slots whose duration is specified by the system. Two signals are often transmitted continuously and these are a dedicated physical data channel DPDCH and dedicated physical control channel DPCCH, these signals are shown in Figure 1. Only DPCCH is transmitted when there is no data. The relative transmission power levels P_D and P_C of the DPDCH and DPCCH channels are regulated so as to maintain a fixed power ratio for a given data type and their combined powers are controlled so as not to exceed an allowable maximum power level P_{max}. Further while maintaining the fixed power ratio, the power level P_C of the DPCCH is adjusted periodically by a closed-loop power control mechanism.

Referring to Figure 2, which is a simplified version of Figure 1, from time to time the base station BS uses the downlink to transmit packet data to an identified mobile station using High-Speed Downlink Packet Access HSDPA. Under the UMTS standard, the mobile station MS must transmit a positive (ACK) or negative (NACK) acknowledgement for each HSDPA packet received, depending for example on the outcome of a cyclic redundancy check (CRC) evaluation.

Referring to Figure 3 the ACKs and NACKs are transmitted as spread spectrum signals on a so-called High-Speed Dedicated Physical Control Channel (HS-DPCCH), whose time slots are not aligned with the time slots on the other uplink channels carrying the continuous uplink signals DPDCH and DPCCH. The relative transmit powers of the ACKs and NACKs are different and the respective transmit powers are determined by the base station BS and notified to the mobile station MS.

If the transmission of an ACK or NACK in parallel with the continuous uplink signals would require more transmit power than is allowed, the transmit power must be reduced. If the adjustment of the respective signal powers is delayed until the CRC in the HSDPA packet is evaluated, in the case of a large

packet it would be difficult, if not impossible, to make the adjustment at a DPCCH slot boundary as specified in the UMTS standard.

To avoid this problem the method in accordance with the present invention causes the transmit power of the other uplink channels , that is , the DPDCH and DPCCH, to be reduced at the timeslot boundary immediately preceding the start of the ACK or NACK transmission. However, as mentioned above, the transmit power for ACKs is required to be different from the transmit power for NACKs. Consequently, if the mobile station MS was to know by how much to reduce the power of the continuous signals DPDCH and DPCCH in time for the slot boundary prior to the start of the ACK or NACK transmission, it would need to complete the CRC evaluation process more quickly than the time allowed by the timing of the ACK/NACK transmission. Since this is not possible, the mobile station MS reduces the transmit power at the time slot prior to the start of the ACK/NACK transmission by an amount corresponding to whichever of ACK or NACK has the higher power requirement P_A or P_N, respectively. In this way, the mobile station MS can ensure that enough transmit power is available for the ACK/NACK transmission regardless of the final outcome of the CRC evaluation process.

The principle is illustrated in Figures 3 and 4. In Figure 3 the mobile station MS is initially transmitting at its maximum allowed power, $P_{max} = P_{C1} + P_{D1}$.

Suppose that P_A is defined to be $2P_C$ and P_N is defined to be equal to P_C.

Then the powers of the DPDCH and DPCCH must be reduced to P_{D2} and P_{C2} , respectively, such that

$P_{C2} + P_{D2} + P_A = P_{max}$

That is, $P_{C2} + P_{D2} + 2P_{C2} = P_{max}$.

The power ratio between the control and data channels is maintained, such that $P_{D2}/P_{C2} = P_{D1}/P_{C1}$.

Thus $P_{C2} = \dfrac{P_{C1} + P_{D1} - P_A}{1 + P_{D1}/P_{C1}}$ or $P_{C2} = \dfrac{P_{C1} + P_{D1}}{3 + P_{D1}/P_{C1}}$

and $P_{D2} = \dfrac{P_{C1} + P_{D1} - P_A}{1 + P_{C1}/P_{D1}}$ or $P_{D2} = \dfrac{P_{C1} + P_{D1}}{1 + 3P_{C1}/P_{D1}}$.

In Figure 4 the broken horizontal line illustrates the maximum allowed transmit power P_{max}. When there is not ACK or NACK to be transmitted then the combined maximum amplitudes of P_{D1} and P_{C1} equal P_{max}. However at the boundary of the frame or time slot immediately preceding the sending of an ACK or NACK, these amplitudes are adjusted by for example reducing DPCCH whilst maintaining the power ratio P_D / P_C constant. Thus capacity is left for the transmission of the higher power one of ACK or NACK, even though the lower power one may be transmitted thereby making the combined transmit power lower than P_{max}.

The flow chart shown in Figure 5 summarises the operations carried out by the secondary station in implementing the method in accordance with the present invention. Block 50 relates to the mobile station MS continuously transmitting the DPDCH and DPCCH signals at a combined transmit power level equal to or less than the maximum allowable power level P_{max}. Block 52 relates to the mobile station receiving packet data in a downlink HSDPA packet data signal. Block 54 denotes the mobile station determining the power levels for the ACK or NACK signal and the greater one of the two levels. Block 56 denotes checking if P_{max} would be exceeded by an uplink signal comprising DPDCH, DPCCH and the higher power of the ACK or NACK signals. If the answer is yes (Y) then in block 58 the scaling stage 36 (Figure 1) of the mobile station scales the power of at least the DPCCH channel so that P_{max} will not be exceeded. The flow chart proceeds to block 60. If the answer in the block 56 is no (N) the flow chart proceeds to the block 60. The block 60 denotes the power control stage 34 (Figure 1) of the mobile station reducing the power of the DPDCH and DPCCH channels at the frame or time slot boundary preceding the transmission of the ACK or NACK. Block 62 relates to the mobile station MS transmitting the ACK or NACK.

When implementing the method in accordance with the present invention the scaling of the DPCCH power may coincide with a requested

power increase, for example due to a closed loop power control process or a change in data format on the DPDCH. In this case, the result of the scaling process in accordance with the present invention may in fact be to increase the DPCCH (+ DPDCH) transmit power, but by a smaller amount than was requested by the closed loop power control process and/or change in DPDCH data format. This situation may arise where the sum of P_{C1} and P_{D1} is less than P_{max}, but the sum of P_{C2} + P_{D2} + the greater of P_A and P_N would be greater than P_{max} if the scaling were not applied.

In another embodiment, the additional signals may carry information other than ACK/NACK signalling; for example, they may carry packet data (as in the proposed enhanced uplink in UMTS) or other signalling information.

In a further non-illustrated embodiment the base station may be required to implement the method in accordance with the present invention rather than the mobile station.

Although the method in accordance with the present invention has been described with reference to a spread spectrum communication system, its teachings may be applied to other systems having transmitter power control.

In the present specification and claims the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. Further, the word "comprising" does not exclude the presence of other elements or steps than those listed.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of telecommunication systems and component parts therefor and which may be used instead of or in addition to features already described herein.

CLAIMS

1. A method of operating a communication system comprising a first station (BS) and a second station (MS), the first and second stations each having transceiving means (12, 38), the second station transmitting a first signal (DPCCH) to the first station, the power of the transmitted first signal not exceeding a predetermined maximum level (P_{max}), wherein in response to the second station wishing to transmit any one of a set of possible additional signals, the transmit power of the first signal is scaled by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

2. A method as claimed in claim 1, characterised in that the set of the possible additional signals comprise a positive acknowledgement signal (ACK) and a negative acknowledgement signal (NACK), in that one of the ACK and NACK is transmitted at a mutually different power level than the other, and in that the scaling in the transmitted power of the first signal assumes that the higher power one of the ACK or NACK is to be transmitted.

3. A method as claimed in claim 1 or 2, wherein the first signal is transmitted in first frames or time slots and the additional signals are transmitted in second frames or time slots, wherein the boundaries between the first frames or time slots are not coincident with the boundaries between the second frames or time slots, characterised in that the transmit power of the first signal is scaled at the frame or time slot boundary immediately preceding the transmission of the additional signal.

4. A method as claimed in claim 1, characterised by the second station transmitting the first signals substantially continuously in successive first frames or time slots, by the first station transmitting to the second station a data packet requiring a response consisting of at least a selected one of the set of possible additional signals, in that the first station requires the response

to be transmitted in a second frame or time slot whose boundaries are different from the boundaries of the first frames or time slots, and in that the power level of at least the first signal is scaled at the boundary of the first frame or time slot immediately preceding the occurrence of the second time slot.

5. A method as claimed in any one of claims 1 to 4, characterised in that the second station determines if the combined power requirement of the first signal and all of the set of possible additional signals exceeds the predetermined maximum level, and, if so, it scales the power requirement of the first signal.

6. A method as claimed in any one of claims 1 to 5, characterised in that the scaling results in a power reduction.

7. A method as claimed in any one of claims 1 to 5, characterised in that in response to the scaling occurring coincidentally with a requirement to increase the power of the first signal, the scaling results in a smaller increase than the requirement.

8. A method as claimed in claim 7, characterised in that the requirement to increase power is due to a regular power control process.

9. A method as claimed in claim 8, characterised in that the regular power control process is a closed loop process and in that the second station receives commands to change power from the first station.

10. A method as claimed in claim 7 or 8, characterised in that the requirement to increase power is due at least in part to a change in parameters or in format of a data signal transmitted from the second station.

11. A method as claimed in any one of claims 1 to 10, characterised in that the first signal and the possible additional signals are transmitted as spread spectrum signals.

12. A communication system comprising a first station (BS) and a second station (MS), the first station and second stations having transceiving means (12, 38), the second station having power control means (34) for controlling the transmitted power level of a first signal (DPCCH) to be transmitted to the first station, wherein the power control means is adapted, in response to determining that the second station wishes to transmit any one of a set of possible additional signals simultaneously with the first signals, to scale the transmit power of the first signal by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

13. A system as claimed in claim 12, characterised by the second station having power scaling means (36) which is adapted, in response to the power control means determining that the combined power requirement of the first signal and the set of possible additional signals exceeding the predetermined maximum level, to scale the power requirements of the first signal.

14. A system as claimed in claim 12 or 13, characterised in that the power scaling means is adapted, in response to the scaling occurring coincidentally with a requirement to increase the power of the first signal, to effect a smaller increase in the scaling than the requirement.

15. A system as claimed in claim 14, characterised by power control means in the first station for effecting a closed loop power control process with the second station and by means in the first station for generating commands instructing the second station to change power.

16. A system as claimed in claim 15, characterised in that power control means in the first station is adapted to generate a command to increase power due at least in part to a change in parameters or in format of a data signal transmitted from the second station.

17. A system as claimed in any one of claims 12 to 16, characterised in that the transceiving means are spread spectrum transceiving means.

18. A second station (MS) for use in a communication system comprising a first station and a second station, the second station including transceiving means (38) for communication with the first station, and power control means (34) for controlling the transmitted power level of a first signal (DPCCH) to be transmitted to the first station, wherein the power control means is adapted, in response to determining that the second station wishes to transmit any one of a set of possible additional signals (ACK or NACK) simultaneously with the first signals, to scale the transmit power of the first signal by an amount which takes into account the greater (or greatest) power requirement of all of the set of the possible additional signals to be transmitted subsequently.

19. A second station as claimed in claim 18, characterised by power scaling means (36) which is adapted, in response to the power control means determining that the combined power requirement of the first signal and the set of possible additional signals exceeding the predetermined maximum level, to scale the power requirements of the first signal.

20. A second station as claimed in claim 19, characterised in that the power scaling means is adapted, in response to the scaling occurring coincidentally with a requirement to increase the power of the first signal, to effect a smaller increase in the scaling than the requirement.

21. A second station as claimed in claim 20, characterised in that power control means in the second station is responsive to commands generated by the first station for effecting a change in power.

22. A second station as claimed in any one of claims 18 or 21, characterised in that the transceiving means is a spread spectrum transceiving means.

ABSTRACT

COMMUNICATION SYSTEM AND METHOD OF OPERATING THE COMMUNICATING SYSTEM

A communication system, for example UMTS (Universal Mobile Telecommunication System), comprises a base station and a plurality of mobile stations. In normal operation the mobile station substantially continuously makes uplink transmissions on certain spread spectrum channels (DPDCH, DPCCH). The maximum allowed power (P_{max}) for these uplink transmissions is specified. However there are occasions when for example receiving packet data from the base station, the receiving mobile station has to transmit an acknowledgement (ACK) or a Non-acknowledgement (NACK) at a power level specified by the base station. In order to keep within the maximum allowed power the total power requirement is determined and if this exceeds P_{max} then at least the DPDCH and DPCCH channels are scaled to allow sufficient power for the transmission of an ACK or NACK. The power scaling is carried-out based on the power required for whichever one of ACK or NACK requires the most power. This avoids reducing the amount of time available to a mobile station for evaluating a CRC used to determine whether an ACK or NACK should be transmitted.

(Figure 3)

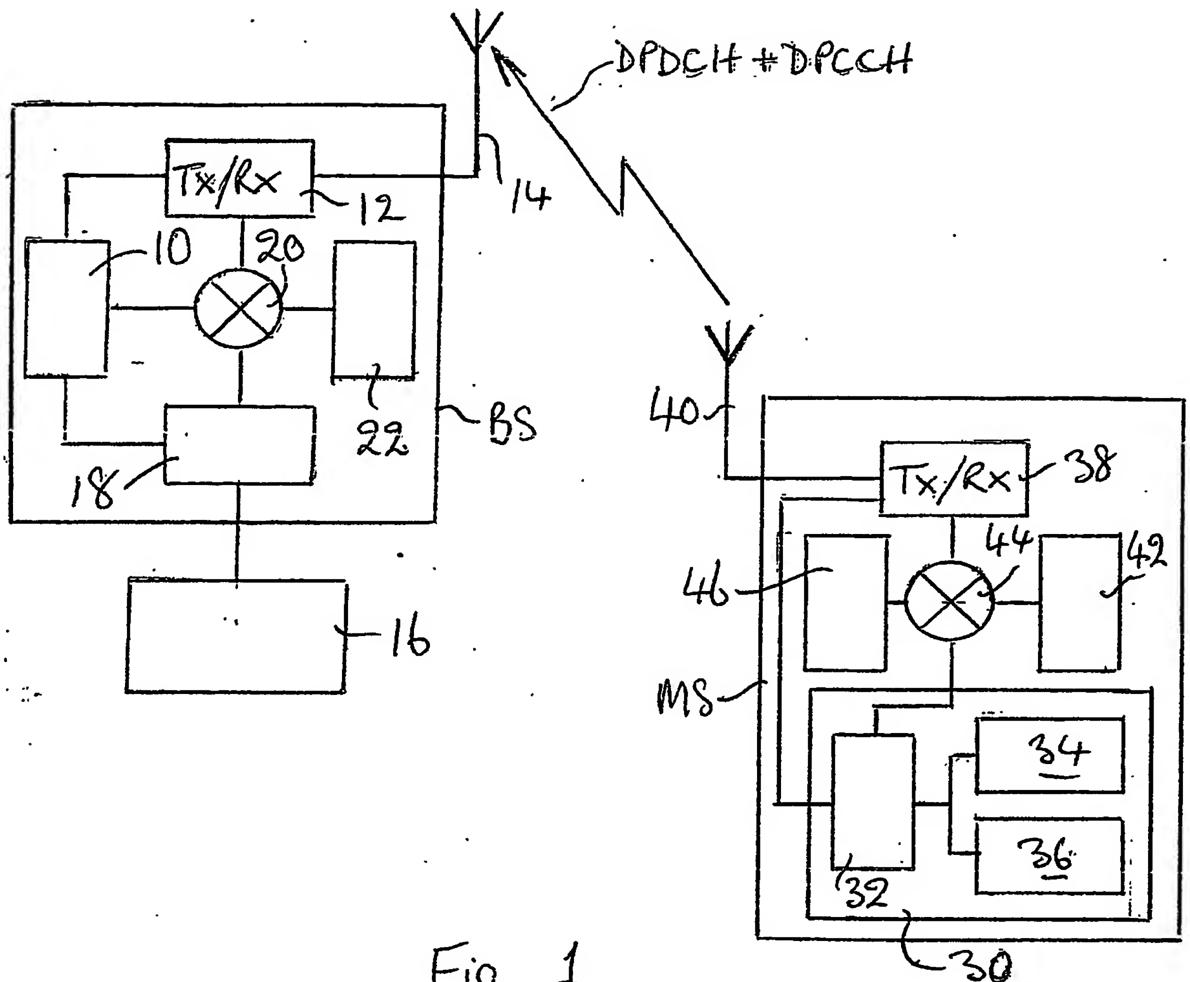
DPDCH + DPCCH
Tx/Rx
12
14
10
20
22
BS
18
16
40
Tx/Rx
38
44
42
46
MS
34
36
32
30

Fig. 1

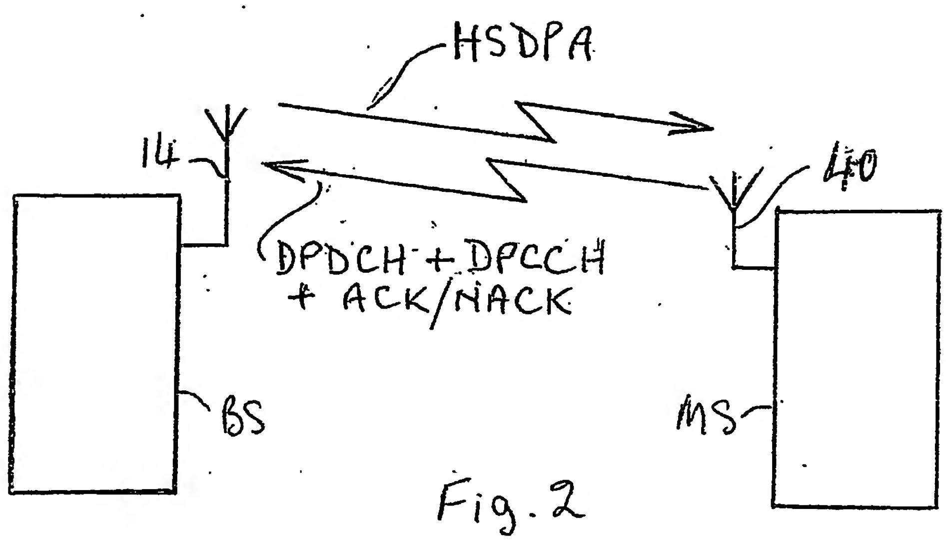
HSDPA
14
40
DPDCH + DPCCH
+ ACK/NACK
BS
MS

Fig. 2

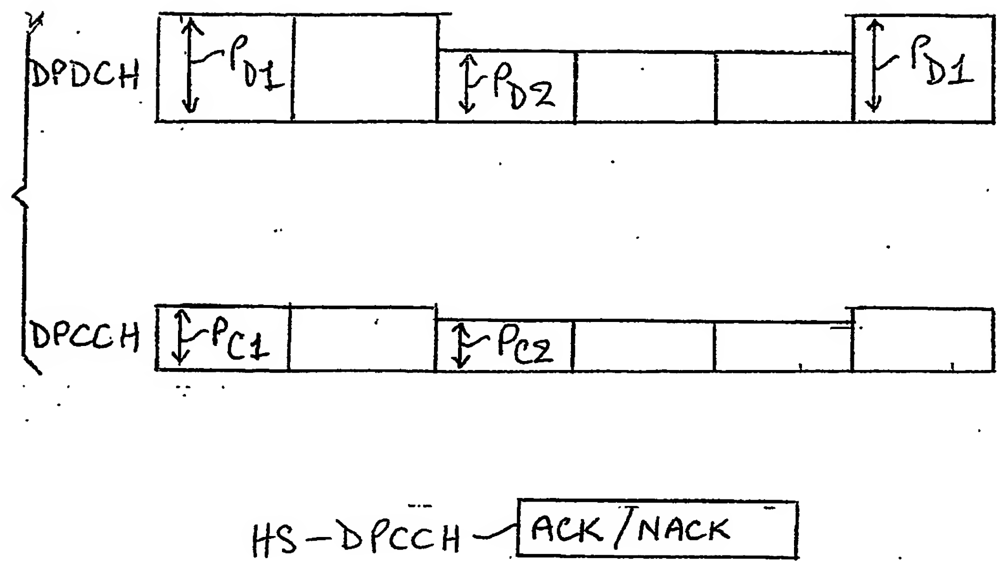
DPDCH
P_{D1}
P_{D2}
P_{D1}
DPCCH
P_{C1}
P_{C2}
HS-DPCCH
ACK/NACK

Fig. 3

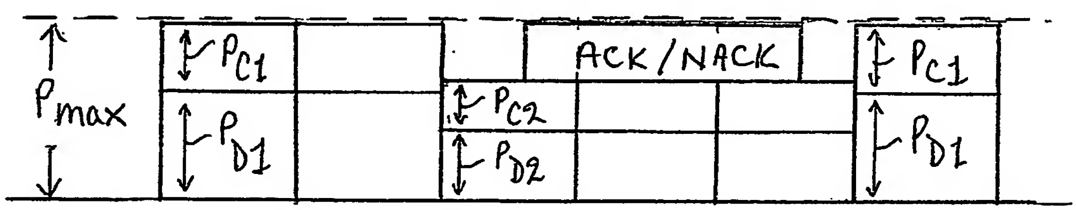
P_{max}
P_{C1}
P_{D1}
ACK/NACK
P_{C2}
P_{D2}
P_{C1}
P_{D1}

Fig. 4

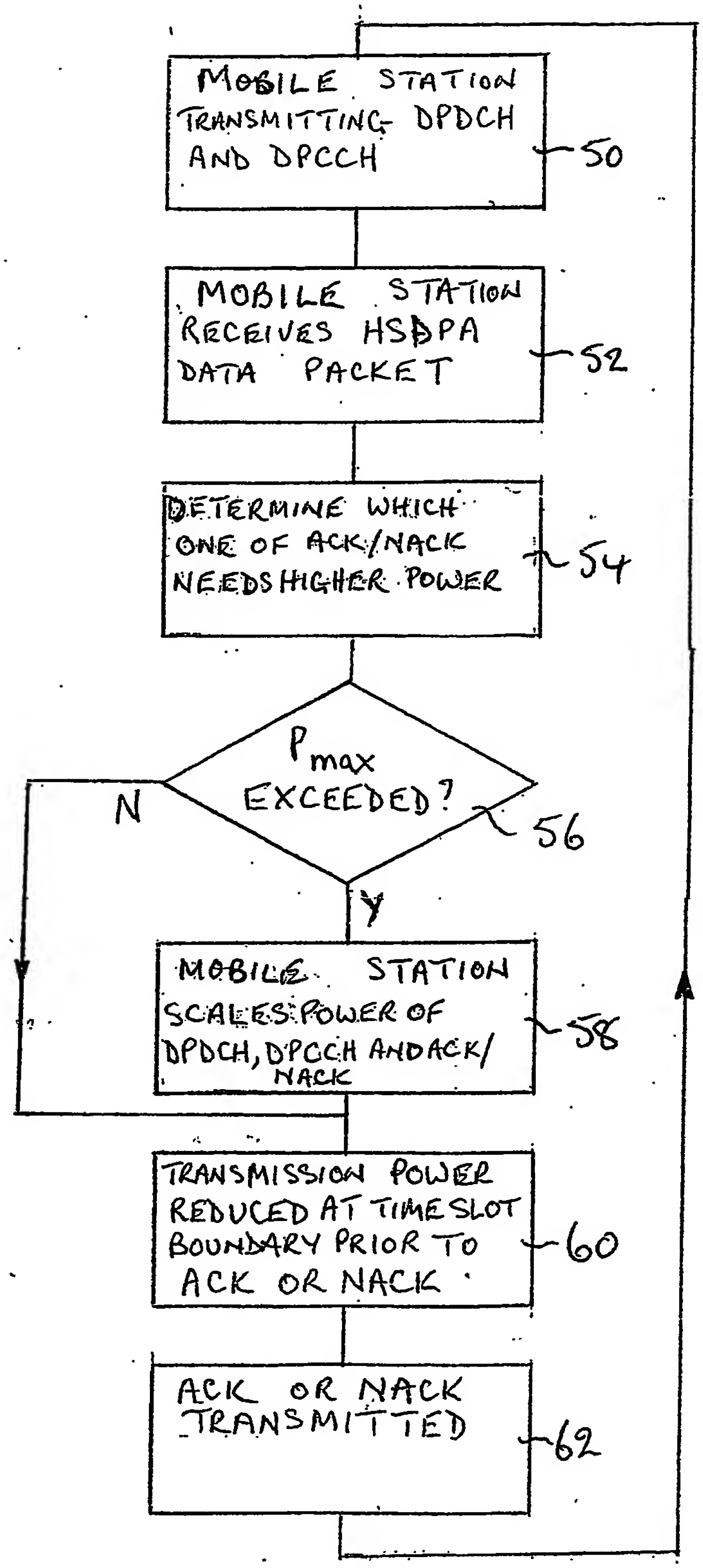
MOBILE STATION TRANSMITTING DPDCH AND DPCCH
50
MOBILE STATION RECEIVES HSDPA DATA PACKET
52
DETERMINE WHICH ONE OF ACK/NACK NEEDS HIGHER POWER
54
P_{max} EXCEEDED?
56
N
Y
MOBILE STATION SCALES POWER OF DPDCH, DPCCH AND ACK/NACK
58
TRANSMISSION POWER REDUCED AT TIMESLOT BOUNDARY PRIOR TO ACK OR NACK
60
ACK OR NACK TRANSMITTED
62

Fig. 5

PCT/IB2004/002630